

FTO Auction Strawman

A. Summary

Transmission capacity that is available after allocation of Catalogued Transmission Rights will be made available to the market through periodic auctions of Financial Transmission Options (FTOs). FTOs grant their holders congestion credits equal to the price difference between the specified withdrawal and injection points. Several types of FTOs can be purchased in the auction, including simple point-to-point FTOs, contingent FTOs linking multiple injection and withdrawal points, and FTOs to and from specified trading hubs. In addition, outstanding FTOs can be sold or “reconfigured”, i.e., exchanged for new injection and withdrawal points. Buyers and sellers will submit bids for their desired injection and withdrawal points, and the auction engine will award FTOs based on an algorithm that maximizes net societal benefit. Revenues from the FTO auction will be placed into RTO West’s congestion management account and used to offset purchases of congestion redispatch.

B. Time frames for FTO auctions

RTO West will hold FTO auctions during the following time frames:

- Daily, prior to the start of the day-ahead scheduling process.
- Monthly
- Seasonally
- Annually
- Longer-term

During the first few years of RTO West operations, it is expected that FTO Auctions will be of shorter duration only, i.e., daily, monthly, and seasonally. Once it has sufficient operational experience, it can determine the conditions under which it can auction longer-term FTOs and grant FTOs for expansion of the transmission system.

C. Calculation of available physical capability

Before each auction, RTO West will calculate and publish the total transmission capability (TTC) and expected CTR use on each potentially constrained system element. These values will determine the physical capability that is available for the FTO auction. RTO West will estimate expected CTR use based on an engineering analysis of the RTO West system. For load-based CTRs such as network service, estimating expected CTR use will involve projecting loads and power flows under a defined set of conditions.

RTO West will determine the conditions to use to calculate TTC and expected CTR use. RTO West will choose the case that that best allows it to meet the revenue target from its congestion management activities, consistent with its corporate risk management policy. In deciding which case to use, RTO West must evaluate the tradeoff between the higher auction revenues it would receive from making more capacity available in the FTO auction and the increased risk of unreimbursed congestion redispatch costs.

It is expected that RTO West will use a conservative set of assumptions for selling longer-term rights due to uncertainty about system conditions. Closer to real time, RTO West will have more information about expected weather, water and transmission system conditions, and will be able to release more capacity into the auction. The following table shows conditions that RTO West *might* use to calculate available physical capability:

Time Frame	Weather Case	Water Case	System Status
Annual or longer	1 in 5 year	1 in 5 year	All elements in service, capacity held out for load growth
Seasonal	Seasonally appropriate case	Best available information	Based on approved PTO maintenance plans
Monthly	Seasonally appropriate case	Best available information	Based on approved PTO maintenance plans
Daily	Best available information	Best available information	Best available information

D. Transmission use of outstanding FTOs

Because FTOs are financial rights that entitle their holders to congestion credits under all conditions, there is no need to estimate the transmission use associated with FTOs (e.g., with a power flow model). Instead, FTO use can be determined precisely for any given system configuration using power flow distribution factors between the specified injection and withdrawal points. FTO use could be calculated exogenously to the auction process and incorporated as a capacity set-aside, similar to CTR use. Alternatively, outstanding FTOs could be placed into the auction with an arbitrarily high sell offer.

~~rather than physical rights that consume a particular amount of transmission capacity, the transmission use associated with outstanding FTOs will be specified by placing those FTOs into the auction with a sell offer of infinity. This will ensure that the auction engine considers expected use of outstanding FTOs on a financial basis, consistent with the use of FTOs that are to be awarded. In other words, RTO West will not try to estimate the power flows that will result from outstanding FTOs, but will financially “reserve” the capacity within the auction process. Outstanding FTOs will not actually change hands unless the FTO owner has submitted a sell offer.~~

E. Types of rights that are available in FTO Auctions

There are two types of FTOs that can be bought or sold in FTO auctions. Each type of right has three variations. The two types of rights are Call Options and Redispatch Obligations. The variations are Simple, Contingent, and Weighted FTOs.

1. Call Option. An FTO Call Option is a right that entitles its holder to receive a congestion credit equal to the difference in Locational Marginal Energy Prices between any specified

withdrawal and injection points, as long as the price difference is positive. There are three variations of Call Options:

- A. Simple Call Option. A Simple Call Option entitles its holder to receive a congestion credit equal to the price difference between any one withdrawal point and any one injection point. For example, a Call Option with an injection point at A and a withdrawal point at B would entitle the holder to receive a congestion credit equal to $P_B - P_A$, where $P_B - P_A > 0$. No payment is required if the price difference is negative.
- B. Contingent Call Option. A Contingent Call Option might be useful for a Scheduling Coordinator with dispatchible generators and/or loads at multiple locations. A Contingent Call Option entitles its holder to receive a congestion credit equal to the largest price difference between any number of injection and withdrawal points. For example, a Call Option with injection points at A and B and withdrawal points at C and D would entitle the holder to receive a congestion credit equal to $\text{Max}(P_C - P_A, P_C - P_B, P_D - P_A, P_D - P_B)$, where $\text{Max}(P_C - P_A, P_C - P_B, P_D - P_A, P_D - P_B) > 0$. No payment is required if the largest price difference is negative.
- C. Weighted Call Option. A Weighted Call Option would be useful to define rights to and from trading hubs. A Weighted Call Option is a right that entitles its holder to receive a congestion credit equal to the weighted price difference between any specified withdrawal and injection points, as long as the weighted price difference is positive. The weights assigned to each injection and withdrawal point are fixed, and are specified by the bidder. For example, a Weighted Call Option with injection points at A and B and withdrawal points at C and D would grant the holder a congestion credit equal to:

$$(X_1 * P_C + X_2 * P_D) - (Y_1 * P_A + Y_2 * P_B)$$

where:

$$(X_1 * P_C + X_2 * P_D) - (Y_1 * P_A + Y_2 * P_B) > 0$$

$$X_1 + X_2 = 1$$

$$Y_1 + Y_2 = 1$$

X_1 and X_2 are the weights associated with the withdrawal points, and Y_1 and Y_2 are the weights associated with the injection points.

2. Redispatch Obligation. [A Redispatch Obligation is similar to an FTO Call, except that the option to exercise the right \(and receive the congestion payment\) is held by RTO West rather than by the customer.](#) A Redispatch Obligation is a right that requires its holder to pay a congestion charge equal to the difference in Locational Marginal Energy Prices between any specified withdrawal and injection points, as long as the price difference is negative. A Redispatch Obligation is the financial equivalent of a forward sale of generator redispatch, allowing additional FTOs to be sold by shifting the risk of honoring the FTOs from RTO West to the seller of the Redispatch Obligation. Combining a Redispatch Obligation and a Call Option between the same points of

injection and withdrawal would create a PJM-style “Obligation”. There are three variations of Redispatch Obligations:

- A. **Simple Redispatch Obligation.** A Simple Redispatch Obligation requires its holder to pay a congestion charge equal to the difference between any one withdrawal and any one injection point, as long as the price difference is negative. For example, a Simple Redispatch Obligation with an injection point at A and a withdrawal point at B would require the holder to pay a congestion charge equal to $P_B - P_A$, where $P_B - P_A < 0$. No credit is granted if the smallest price difference is positive.
- B. **Contingent Redispatch Obligation.** A Contingent Redispatch Obligation might be useful for a supplier with dispatchable generators at multiple locations. A Contingent Redispatch Obligation requires its holder to pay a congestion charge equal to the smallest (i.e., most negative) price difference between any number of injection and withdrawal points. For example, a Call Option with injection points at A and B and withdrawal points at C and D would require the holder to pay a congestion charge equal to $\text{Min}(P_C - P_A, P_C - P_B, P_D - P_A, P_D - P_B)$, where $\text{Min}(P_C - P_A, P_C - P_B, P_D - P_A, P_D - P_B) < 0$. No credit is granted if the smallest price difference is positive.
- C. **Weighted Redispatch Obligation.** A Weighted Redispatch Obligation is the mechanism for selling forward redispatch to and from trading hubs. A Weighted Redispatch Obligation is a right that requires its holder to pay a congestion charge equal to the weighted price difference between any specified withdrawal and injection points, as long as the weighted price difference is negative. The weights assigned to each injection and withdrawal point are fixed, and are specified by the bidder. For example, a Weighted Redispatch Obligation with injection points at A and B and withdrawal points at C and D would require the holder to pay a congestion charge equal to equal to:

$$(X_1 * P_C + X_2 * P_D) - (Y_1 * P_A + Y_2 * P_B)$$

where:

$$(X_1 * P_C + X_2 * P_D) - (Y_1 * P_A + Y_2 * P_B) < 0$$

$$X_1 + X_2 = 1$$

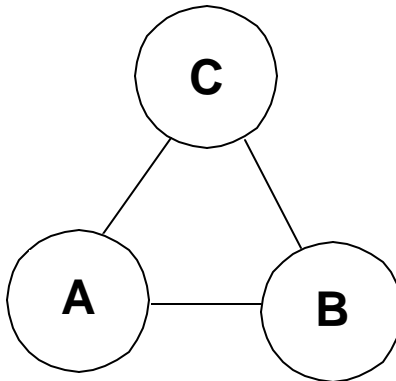
$$Y_1 + Y_2 = 1$$

X_1 and X_2 are the weights associated with the withdrawal points, and Y_1 and Y_2 are the weights associated with the injection points.

The following table illustrates the difference between Simple FTO Call Options, Redispatch Obligations, and PJM-style obligations.

Ranked Hour	Price Spread: P(B)-P(A)	Value of A-B Right			Value of B-A Right		
		PJM-Style Obligation	RTO West FTO Call	RTO West Redispatch Obligation	PJM-Style Obligation	RTO West FTO Call	RTO West Redispatch Obligation
1	\$ 12.00	\$ 12.00	\$ 12.00	\$ -	\$ (12.00)	\$ -	\$ (12.00)
2	\$ 10.00	\$ 10.00	\$ 10.00	\$ -	\$ (10.00)	\$ -	\$ (10.00)
3	\$ 8.00	\$ 8.00	\$ 8.00	\$ -	\$ (8.00)	\$ -	\$ (8.00)
4	\$ 6.00	\$ 6.00	\$ 6.00	\$ -	\$ (6.00)	\$ -	\$ (6.00)
5	\$ 4.00	\$ 4.00	\$ 4.00	\$ -	\$ (4.00)	\$ -	\$ (4.00)
6	\$ 2.00	\$ 2.00	\$ 2.00	\$ -	\$ (2.00)	\$ -	\$ (2.00)
7	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
8	\$ (2.00)	\$ (2.00)	\$ -	\$ (2.00)	\$ 2.00	\$ 2.00	\$ -
9	\$ (4.00)	\$ (4.00)	\$ -	\$ (4.00)	\$ 4.00	\$ 4.00	\$ -
10	\$ (6.00)	\$ (6.00)	\$ -	\$ (6.00)	\$ 6.00	\$ 6.00	\$ -

Contingent and weighted rights are mathematical combinations of simple injection-withdrawal rights. All rights are evaluated based on the amount of transmission capacity they use. The following graphic illustrates the transmission use of contingent and weighted rights relative to simple rights.



Transmission use resulting from 100 MW right

Path	FTO Calls					Redispatch Obligations				
	A-B	C-B	A	C-B	A,C-B	A-B	C-B	A	C-B	A,C-B
AB	67	33		67	50	0	0		0	0
AC	33	0		33	17	0	-33		-33	-17
BC	0	0		0	0	-33	-67		-67	-50
BA	0	0		0	0	-67	-33		-67	-50
CA	0	33		33	17	-33	0		-33	-17
CB	33	67		67	50	0	0		0	0

A-B = Simple right from A to B

A C-B = Contingent right from A or C to B

A,C-B = Weighted right from A and C to B

A 100 MW simple right from A to B consumes 67 MW on path AB and 33 MW each on paths AC and CB. A contingent right A C-B (a right from A or C to B) consumes transmission capacity equal to Max(A-B,C-B). A weighted right A,C-B consumes capacity

equal to $\text{Avg}(A-B, C-B)$. Any right that consumes a unique, definable amount of transmission capacity will have a unique, definable value in an FTO auction, and bids for such a right can be evaluated against competing bids for the same or other types of rights.

F. Form of bids and offers

Auction participants can place bids to purchase FTO Calls between one or more injection and withdrawal points, offers to sell FTO Puts, and offers to sell FTO Calls to which they hold clear title. Bids and offers must contain the following information:

- Type (FTO Call or Redispatch Obligation)
- Variation (Simple, Contingent, Weighted)
- Quantity
- Price
- Injection point(s) or hub
- Withdrawal point(s) or hub
- Injection point weights, if applicable
- Withdrawal point weights, if applicable

G. Selecting Winning Bids

Once RTO West has estimated the available physical capacity and assembled all of the bids and offers, the auction engine will determine the optimal allocation of transmission capacity among all bidders. The auction engine will be a linear optimization program that awards capacity to those that value it most by maximizing ~~auction revenue~~ net societal benefit, i.e., the product of the quantity of each FTO awarded and the bid/offer for that FTO, summed across all FTOs awarded. Transmission system limitations function as constraints to ensure that the resulting capacity allocation is simultaneously feasible, given the set of system conditions defined by RTO West.

The auction logic is analogous to the state estimator that optimizes the dispatch of energy and ancillary services during the day-ahead and real-time periods. The state estimator uses the supply bid prices to select the energy and ancillary service quantities that would minimize the total system dispatch cost, subject to transmission system limitations, while the FTO auction engine uses bid and offer prices to select the FTO quantities that, effectively, maximize the total auction revenue.

H. Determining Auction Clearing Prices

The auction clearing price for each FTO will be equal to the change in net economic value (i.e., net ~~auction proceeds~~ societal benefit) that would result from awarding an additional ~~1~~ MW of that FTO. This is again analogous to the day-ahead and real-time process, in which the market clearing price for each location is equal to the change in total dispatch costs from serving an additional MW of load at that location.

Each bidder will pay the applicable auction clearing price for those FTOs awarded in the FTO auction. Each FTO seller will be paid the auction clearing price for those FTOs selected for sale in the FTO auction.

I. Reconfiguration of outstanding FTOs

The FTO Auction will allow holders of outstanding FTOs to reconfigure their rights by selling them in the auction and using the auction proceeds to purchase FTOs with different injection and/or withdrawal point(s). All FTOs bought or sold will be settled at the appropriate auction clearing price. Customers can specify a desired quantity of FTOs, and will be billed or credited for the difference between the value of the FTOs sold and the value purchased. Alternatively, the customer could specify that the value of the FTOs awarded should not exceed the credit from the FTOs sold.

Any [type-variation](#) of FTO can be reconfigured into any other type of FTO. For example, a simple FTO between Node A and Node B could be reconfigured into rights from Node A to a hub, and from the hub to Node B. Or contingent rights from multiple injection points to multiple withdrawal points could be reconfigured as a set of individual injections and withdrawals. [In either case, the customer bears the difference in value between the outstanding rights and the reconfigured rights.](#)

J. Early release of Standard CTRs

Holders of Standard CTRs that are directly scheduled with RTO West may use the FTO auctions for early lockdown and release of their Standard CTRs. Standard CTRs are CTRs that are defined as a given quantity of unconditional rights between specified injection and withdrawal points, and can be any of the Simple, Contingent or Weighted variety. Standard CTR holders will be paid the auction clearing price for CTRs placed into the auction, and can request any type of FTOs, similar to reconfiguring FTOs.

K. Allocation of auction revenue

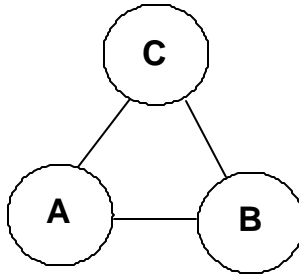
Proceeds from the FTO Auction will be placed into RTO West's congestion management account and used to provide hedges against congestion costs incurred during the day-ahead scheduling process. Surplus revenues from the congestion management account are placed into the Revenue Replacement Pool and allocated to Participating Transmission Owners to compensate for the loss of revenues from the elimination of short-term and non-firm transmission sales.

L. Open Issues

- [1. If FTOs are used as a "tie-breaker" in case schedule curtailment is needed, will allowing the sale of Redispatch Obligations mean that the tie-breaker will be ineffective?](#)
- [2. Should RTO West allow contingent and weighted configurations of rights, or should this be left to "the market"?](#)
- [3. Should the auction be a clearing price or as-bid auction?](#)
- [4. Is there a way to calculate the lowest possible winning bid for each requested FTO? I.e., the clearing price only tells you the lowest bid that would set the clearing price, which may or may not be the lowest bid needed to win.](#)
- [5. Does allowing standard CTRs to be reconfigured increase their value by increasing "fungibility"? If no, then is there any problem with using the FTO auction as the mechanism for early lockdown? If yes, then how will early lockdown be accommodated?](#)

L.M. Examples

Example 1a: Simple FTO Calls



Path	Rating	Existing Use
AB	100	0
AC	100	0
BC	100	0
BA	100	0
CA	100	0
CB	100	0

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$12.00)
Quantity Requested	200	200	100	0
Type	Option	Option	Option	Option
Variation	Simple	Simple	Simple	Simple
Injection Points	C	A	C	A
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	100	100	-	-	200
Societal Benefit	\$1,500.00	\$1,000.00	\$0.00	\$0.00	\$2,500.00
Auction Revenue	\$1,500.00	\$1,000.00	\$0.00	\$0.00	\$2,500.00
FTO Price	\$15.00	\$10.00	N/A	N/A	-

Transmission Use

Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	33	67	-	-	100
AC	-	33	-	-	33
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	33	-	-	-	33
CB	67	33	-	-	100

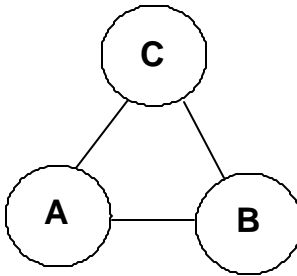
FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- Bids are for I/W pairs, e.g., Bid 1 is \$15 for C-B spread.
- Bids 1 and 2 are accepted, Bid 3 is rejected.
- Two constraints are binding: AB, and CB.
- The shadow prices (value of 1 more MW of Tx capacity) are \$5 for path AB and \$20 for path CB. Shadow prices are function of bids.
- Simple FTO prices are function of shadow prices and power flows resulting from bids, e.g., C-B FTO is $(0.67 * \$20 + 0.33 * \$5) = \$15.00$.
- FTOs do not result in symmetric prices (B-A \neq -(A-B)), because options do not allow consideration of counterflows.
- Contingent FTO prices function of shadow prices and maximum power flows, e.g., A C-B = $(0.67 * \$20 + 0.67 * \$5) = \$16.67$.
- Price of Contingent FTO always greater than or equal to price of individual Simple FTOs, less than or equal to sum of Simple FTOs.
- Weighted FTO prices weighted average of Simple FTO prices, e.g., A,C-B = $(0.5 * \$10) + (0.5 * \$15) = \$12.50$.
- Societal Benefit'' is bids times quantity awarded, while auction revenue is clearing price times quantity awarded. Auction engine maximizes societal benefit, which includes buyer surplus (difference between willingness to pay and actual price paid). The calculations are identical in this example.

Example 1b: Weighted FTO Calls



Path	Rating	Existing Use
AB	100	0
AC	100	0
BC	100	0
BA	100	0
CA	100	0
CB	100	0

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$12.00)
Quantity Requested	200	200	100	0
Type	Option	Option	Option	Option
Variation	Weighted	Weighted	Weighted	Weighted
Injection Points	A,C	A	C	A,C
Withdrawal Points	B	B,C	A,B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	114	64	64	-	243
Societal Benefit	\$1,712.79	\$643.60	\$643.60	\$0.00	\$3,000.00
Auction Revenue	\$1,712.79	\$643.60	\$643.60	\$0.00	\$3,000.00
FTO Price	\$15.00	\$10.00	\$10.00	N/A	-

Transmission Use

Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	57	32	11	-	100
AC	19	32	-	-	51
BC	-	11	-	-	11
BA	-	-	11	-	11
CA	19	-	32	-	51
CB	57	11	32	-	100

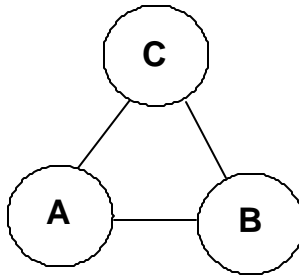
FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$15.00		A	B	\$15.00
AC	\$0.00		A	C	\$5.00
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$5.00
CB	\$15.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$5.00	A,B	C	\$2.50
AnC	B	\$20.00	A,C	B	\$15.00
BnC	A	\$5.00	B,C	A	\$2.50
C	AnB	\$15.00	C	A,B	\$10.00
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$15.00	A	B,C	\$10.00

Notes:

- Bids are for I/W combinations, e.g., Bid 1 is \$15 for A,C-B spread.
- Bids 1, 2 and 3 are all partially accepted.
- Two constraints are binding, AB and CB, with shadow prices of \$15 each.
- This example allows more FTOs to be awarded than Example 1a (243 vs. 200), because more use is made of the non-binding paths (AC, BC, BA and CA).

Example 1c: Contingent FTO Calls



Path	Rating	Existing Use
AB	100	0
AC	100	0
BC	100	0
BA	100	0
CA	100	0
CB	100	0

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$19.00	\$15.00	\$14.00	(\$12.00)
Quantity Requested	200	200	100	0
Type	Option	Option	Option	Option
Variation	Contingent	Contingent	Contingent	Contingent
Injection Points	A,C	A	C	A,C
Withdrawal Points	B	B,C	A,B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	0	100	100	-	200
Societal Benefit	\$0.00	\$1,500.00	\$1,400.00	\$0.00	\$2,900.00
Auction Revenue	\$0.00	\$1,500.00	\$1,350.00	\$0.00	\$2,850.00
FTO Price	\$19.00	\$15.00	\$13.50	N/A	-

Transmission Use

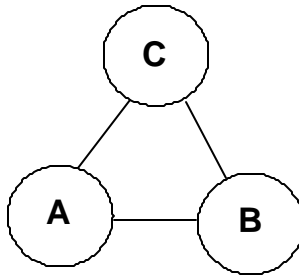
Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	0	67	33	-	100
AC	0	67	-	-	67
BC	-	33	-	-	33
BA	-	-	33	-	33
CA	0	-	67	-	67
CB	0	33	67	-	100

FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$16.50		A	B	\$15.00
AC	\$0.00		A	C	\$5.50
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$4.00
CB	\$12.00		C	B	\$13.50
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$5.50	A,B	C	\$2.75
AnC	B	\$19.00	A,C	B	\$14.25
BnC	A	\$4.00	B,C	A	\$2.00
C	AnB	\$13.50	C	A,B	\$8.75
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$15.00	A	B,C	\$10.25

Notes:

- Bids are for I/W combinations, e.g., Bid 1 is \$19 for A C-B spread.
- Two paths are binding, AB and CB, with shadow prices of \$16.50 and \$12.00.
- Bid 1 rejected, because it uses both binding paths in the forward direction.
- Contingent FTOs consume more transmission. Fewer FTOs are awarded than in Example 1b (200 vs. 245).
- The same number of FTOs is awarded as in Example 1a, because the contingent rights make more use of the non-binding paths (AC, BC, BA and CA) than simple rights, but do not make more use of the binding paths.
- The bids are higher in this example than in Example 1a, because the products being bid on are more valuable. Thus, the auction results in more revenue for the same number of rights awarded.
- “Societal Benefit” calculation (bids times quantity awarded) is slightly different from auction revenue because Bid 3 does not set the clearing price. Since the clearing price is lower than the bid price, some net benefit accrues to participants rather than to RTO West (\$50 to Bid 3, in this case).

Example 1d: Redispatch Obligation Offered

Path	Rating	Existing Use
AB	100	0
AC	100	0
BC	100	0
BA	100	0
CA	100	0
CB	100	0

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$12.00)
Quantity Requested	200	200	100	100
Type	Option	Option	Option	Option
Variation	Simple	Simple	Simple	Weighted
Injection Points	C	A	C	A,C
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	150	150	-	100	400
Societal Benefit	\$2,250.00	\$1,500.00	\$0.00	(\$1,200.00)	\$2,550.00
Auction Revenue	\$2,250.00	\$1,500.00	\$0.00	(\$1,250.00)	\$2,500.00
FTO Price	\$15.00	\$10.00	N/A	(\$12.50)	-

Transmission Use

Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	50	100	-	(50)	100
AC	-	50	-	(17)	33
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	50	-	-	(17)	33
CB	100	50	-	(50)	100

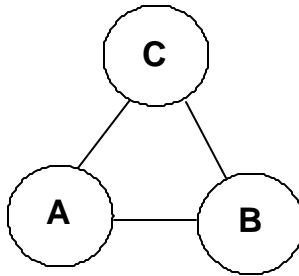
FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- This example shows the effect of offering a redispatch obligation in addition to available capacity.
- Bid 4 is a \$12 sell offer for weighted redispatch obligation A,C-B.
- Bid 4 is accepted and paid the clearing price of \$12.50.
- This allows additional 50 MW of FTOs to be sold, relative to Example 1a, to each of Bids 1 and 2.
- Negative auction revenue indicates payment from RTO West to seller.
- RTO West doesn't take position, only uses the auction as a matching mechanism between willing buyers and sellers.
- The auction clears gross revenue of \$3,750 from buyers, \$1,250 more than in Example 1a. This amount is paid to the seller of the redispatch obligation (Bid 4).
- "Societal Benefit" calculation (bids times quantity awarded) is again different from auction revenue because Bid 4 does not set the clearing price. Some net benefit accrues to participants rather than RTO West (\$50 to Bid 4, in this case).

Example 2a: Incorporating Expected CTR Use



Path	Rating	Existing Use
AB	100	30
AC	100	30
BC	100	-60
BA	100	-30
CA	100	-30
CB	100	60

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$12.00)
Quantity Requested	200	200	100	0
Type	Option	Option	Option	Option
Variation	Simple	Simple	Simple	Weighted
Injection Points	C	A	C	A,C
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	10	100	-	-	110
Societal Benefit	\$150.00	\$1,000.00	\$0.00	\$0.00	\$1,150.00
Auction Revenue	\$150.00	\$1,000.00	\$0.00	\$0.00	\$1,150.00
FTO Price	\$15.00	\$10.00	N/A	N/A	-

Transmission Use

Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	3	67	-	-	70
AC	-	33	-	-	33
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	3	-	-	-	3
CB	7	33	-	-	40

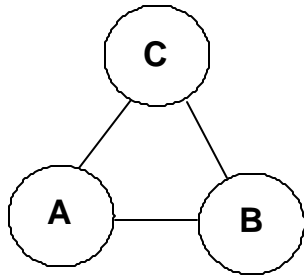
FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- This example assumes CTR use of 60 MW on CB and 30 MW each on CA and AB.
- Transmission capacity available in the auction is now constrained to TTC less the expected CTR use.
- The engine awards 100 MW of FTOs to Bid 2, despite lower bid than Bid 1, because the pattern of underlying CTR use falls more heavily on the CB path. Bid 2 makes more valuable use of remaining capacity by using more of AB.
- Bid 1 gets remaining 10 MW of capacity.

Example 2b: Expected CTR Use with Obligation



Path	Rating	Existing Use
AB	100	30
AC	100	30
BC	100	-60
BA	100	-30
CA	100	-30
CB	100	60

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$12.00)
Quantity Requested	200	200	100	100
Type	Option	Option	Option	Option
Variation	Simple	Simple	Simple	Weighted
Injection Points	C	A	C	A,C
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	60	150	-	100	310
Societal Benefit	\$900.00	\$1,500.00	\$0.00	(\$1,200.00)	\$1,200.00
Auction Revenue	\$900.00	\$1,500.00	\$0.00	(\$1,250.00)	\$1,150.00
FTO Price	\$15.00	\$10.00	N/A	(\$12.50)	-

Transmission Use

Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	20	100	-	(50)	70
AC	-	50	-	(17)	33
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	20	-	-	(17)	3
CB	40	50	-	(50)	40

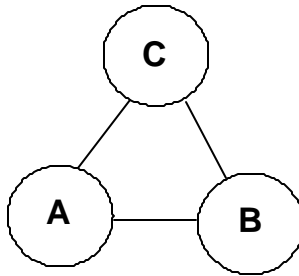
FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- This example shows that allowing sale of redispatch obligations can enhance liquidity when CTR use takes up the majority of valuable transmission capacity.
- Accepting redispatch obligation allows issuance of 100 MW additional FTOs relative to Example 2a, 50 MW each to Bid 1 and Bid 2.
- Allowing the redispatch obligation has increased net societal benefit by \$50, though auction revenue is unchanged (increase accrues to Bid 4).

Example 3a: Incorporating Outstanding FTO



Path	Rating	Existing Use
AB	100	0
AC	100	0
BC	100	0
BA	100	0
CA	100	0
CB	100	0

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	#####	(\$12.00)
Quantity Requested	200	200	50	0
Type	Option	Option	Option	Option
Variation	Simple	Simple	Simple	Weighted
Injection Points	C	A	A	A,C
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	100	50	50	-	200
Societal Benefit	\$1,500.00	\$500.00	#####	\$0.00	#####
Auction Revenue	\$1,500.00	\$500.00	\$500.00	\$0.00	\$2,500.00
FTO Price	\$15.00	\$10.00	\$10.00	N/A	-

Transmission Use

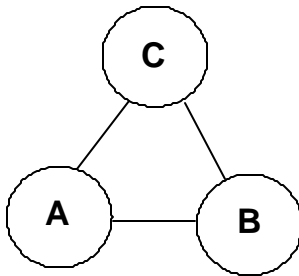
Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	33	33	33	-	100
AC	-	17	17	-	33
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	33	-	-	-	33
CB	67	17	17	-	100

FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- This example shows 50 MW outstanding A-B FTO.
- In this example, outstanding A-B FTO placed into auction with arbitrarily high sell price (Bid 3).
- This is one way to account for FTO use. Functions like a rock in a bathtub, i.e., takes up space on the transmission grid.
- The outstanding A-B FTO consumes transmission that was allocated to Bid 2 in Example 1a.
- Bid 1 is now awarded 100 MW of FTOs.
- This result is different from Example 2a because existing use is on AB rather than CB.
- No actual revenue is collected from holder of outstanding A-B FTO.
- “Societal Benefit” is arbitrarily large in this case since Bid 3 is indeterminate.
- Could also incorporate transmission use of FTO into “expected uses”. Key distinction between FTO and CTR is that there is no need to *estimate* transmission consumption from FTO – FTO uses a precisely defined quantity of capacity on each path.

Example 3b: Reselling a Contingent FTO

Path	Rating	Existing Use
AB	100	67
AC	100	33
BC	100	0
BA	100	0
CA	100	33
CB	100	67

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$15.00)
Quantity Requested	200	200	100	100
Type	Option	Option	Option	Option
Variation	Simple	Simple	Contingent	Contingent
Injection Points	C	A	A,C	A,C
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	100	100	-	100	300
Societal Benefit	\$1,500.00	\$1,000.00	\$0.00	(\$1,500.00)	\$1,000.00
Auction Revenue	\$1,500.00	\$1,000.00	\$0.00	(\$1,666.67)	\$833.33
FTO Price	\$15.00	\$10.00	N/A	(\$16.67)	-

Transmission Use

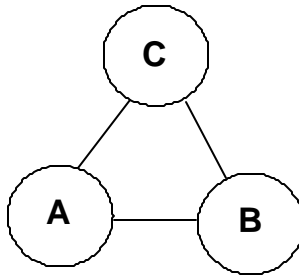
Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	33	67	-	(67)	33
AC	-	33	-	(33)	0
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	33	-	-	(33)	0
CB	67	33	-	(67)	33

FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- In this example, the holder of a 100 MW A C-B FTO wants to sell it.
- FTO use calculated prior to auction and accounted for under “Existing Use”. This is another option for how to account for FTO use.
- Outstanding A C-B FTO placed into auction sell offer of \$15 (Bid 4).
- Holder of A C-B FTO paid the clearing price of \$16.67. Reaps net “seller surplus” of \$167.
- Sale of the A C-B FTO allows the full capacity of the system to be awarded to Bids 1 and 2 (i.e., same result as Example 1a).

Example 4a: CTR with “optionality”

Path	Rating	Existing Use
AB	100	67
AC	100	33
BC	100	0
BA	100	0
CA	100	33
CB	100	67

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$12.00)
Quantity Requested	200	200	100	0
Type	Option	Option	Option	Option
Variation	Simple	Simple	Contingent	Contingent
Injection Points	C	A	A,C	A,C
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	33	33	-	-	67
Societal Benefit	\$500.00	\$333.33	\$0.00	\$0.00	\$833.33
Auction Revenue	\$500.00	\$333.33	\$0.00	\$0.00	\$833.33
FTO Price	\$15.00	\$10.00	N/A	N/A	-

Transmission Use

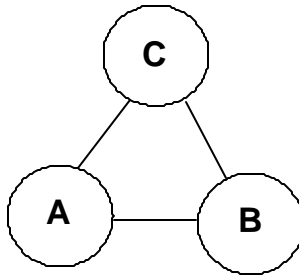
Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	11	22	-	-	33
AC	-	11	-	-	11
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	11	-	-	-	11
CB	22	11	-	-	33

FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- This example shows the effect of a CTR with “optionality”: a 100 MW A C-B CTR.
- This single, 100 MW CTR consumes two-thirds of the capacity on critical the CB and AB paths.
- Only 33 MW of FTOs are awarded to each of Bid 1 and Bid 2.

Example 4b: Early scheduling of CTR with “optionality”

Path	Rating	Existing Use
AB	100	67
AC	100	33
BC	100	0
BA	100	0
CA	100	33
CB	100	67

Bids

	Bid 1	Bid 2	Bid 3	Bid 4
Bid/Offer Price	\$15.00	\$10.00	\$10.00	(\$15.00)
Quantity Requested	200	200	100	100
Type	Option	Option	Option	Option
Variation	Simple	Simple	Contingent	Contingent
Injection Points	C	A	A,C	A,C
Withdrawal Points	B	B	B	B

Awards

	Bid 1	Bid 2	Bid 3	Bid 4	Total
Quantity Awarded	100	100	-	100	300
Societal Benefit	\$1,500.00	\$1,000.00	\$0.00	(\$1,500.00)	\$1,000.00
Auction Revenue	\$1,500.00	\$1,000.00	\$0.00	(\$1,666.67)	\$833.33
FTO Price	\$15.00	\$10.00	N/A	(\$16.67)	-

Transmission Use

Transmission Path	Bid 1	Bid 2	Bid 3	Bid 4	Total
AB	33	67	-	(67)	33
AC	-	33	-	(33)	0
BC	-	-	-	-	-
BA	-	-	-	-	-
CA	33	-	-	(33)	0
CB	67	33	-	(67)	33

FTO Clearing Prices

Transmission Path Shadow Prices			Simple FTO		
Transmission Path	Price		Injection	Withdrawal	Price
AB	\$5.00		A	B	\$10.00
AC	\$0.00		A	C	\$1.67
BC	\$0.00		B	C	\$0.00
BA	\$0.00		B	A	\$0.00
CA	\$0.00		C	A	\$6.67
CB	\$20.00		C	B	\$15.00
Contingent FTO			Weighted FTO (all weights = 0.5)		
Injection	Withdrawal	Price	Injection	Withdrawal	Price
AnB	C	\$1.67	A,B	C	\$0.83
AnC	B	\$16.67	A,C	B	\$12.50
BnC	A	\$6.67	B,C	A	\$3.33
C	AnB	\$15.00	C	A,B	\$10.83
B	AnC	\$0.00	B	A,C	\$0.00
A	BnC	\$10.00	A	B,C	\$5.83

Notes:

- In this example, the holder of a standard 100 MW A C-B CTR wants to exercise “early lockdown” of CTR optionality by foregoing right to schedule from A to B.
- CTR holder places A C-B CTR into auction (Bid 4), simultaneously places \$15 bid for C-B FTO (Bid 1).
- CTR holder has placed a reserve price of \$15 on the CTR.
- The CTR holder is awarded the full 100 MW of C-B FTOs.
- CTR holder paid clearing price of \$16.67 for A C-B CTR, pays \$15 for C-B FTO.
- The capacity left over from sale of A C-B CTR is sold to Bid 2 as A-B FTOs.
- CTR holder receives net payment of \$1,667 – \$1,500 = \$167 for foregoing A-B flexibility.
- RTO West receives same auction revenue as in Example 4a, but more rights sold.
- Standardization of CTR allows precise calculation of transmission consumption, similar to an FTO. Non-standard CTRs, e.g., curtailable, load- or resource-specific, must use a different process.
- Because this CTR is standard, the result is identical to Example 3b.